

## ***Appendix Four***

### **Study Review of Hypersensitivity of Human Subjects to Environmental Electric and Magnetic Field Exposure**

# STUDY REVIEW OF HYPERSENSITIVITY OF HUMAN SUBJECTS TO ENVIRONMENTAL ELECTRIC AND MAGNETIC FIELD EXPOSURE

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## SUMMARY

Hypersensitivity to exposure to electric and magnetic fields (EMF) has been reported for nearly 20 years; however, the literature on the subject is still very limited. Apart from researchers from Sweden and, at a smaller scale, Norway, very few original papers have been published on the subject. In North America, the nearly complete lack of published reports on the subject is striking.

Nearly all the literature published to date is concerned with a dermatological “syndrome” which consists of mainly subjective symptoms (itching, burning, dryness) and few objective symptoms (redness, dryness) appearing after starting to work with video display units (VDU) and decreasing during absence from work. It usually has a good prognosis. Case-controls as well as some good but limited double-blind trials have not found any clear relationship between this syndrome and exposure to EMF. Most of the evidence pleads for a role of the management of the VDU work (workload, stress) and possibly some other physical factors (humidity, temperature). If EMF exposure could play a role in the apparition of this syndrome, it seems rather a minor one.

The “general syndrome” has been rarely described, but seems more problematic because of its poor prognosis. The symptoms often associated with skin disorders are mainly of “neurasthenic” type and can cover a lot of nonspecific symptoms present in other atypical syndromes such as “multiple chemical sensitivity” or “chronic fatigue.” Most of these symptoms are allegedly triggered by exposure to different sources of EMF. But there have been no etiologic studies published on the subject apart from one sketchy trial.

From this short review, it appears that *hypersensitivity to environmental electric and magnetic fields* is an unclear health problem. Apart from VDU skin disorders, very few epidemiological studies have considered such health problems, and controlled experiments results do not support a causal role for EMF exposure. The data available could hardly be used for risk assessment purposes, but this is an area which deserves further research.

## 1. INTRODUCTION

Hypersensitivity of human subjects to environmental electric and magnetic fields has been reported quite recently in the medical literature. Descriptions of possible allergic reactions to exposure to “electrical” environments have been reported mainly from European countries, especially Nordic countries. But the reports and probably the cases seem to have increased so rapidly that some authors have labeled this a “new environmental epidemic.” (Lidén, 1996)

While the clinical picture was mainly dermatological at the beginning and mostly associated with work on video display units (VDU) (Lidén and Wahlberg, 1985a), it has been extended to several health problems triggered by different kinds of exposure to electrical and magnetic fields. Health consequences can be so serious for some people that they lead to lengthy sick leaves and even sometimes to change of jobs and homes.

Studies of hypersensitive people are particularly difficult to conduct since symptoms are nonspecific and such effects could be easily diluted in general population studies. Nevertheless, there is a need for rigorous studies to evaluate the nature and extent of the problem and its origin in order to take it into account eventually in the assessment of the risk of human exposure to electric and magnetic fields.

This paper presents a brief overview of the scientific literature published to date on the subject with a special focus on the possible causal relationship of exposure to electric or magnetic fields of extremely low frequencies. For that purpose, a Medline search was carried out from January, 1990 through September, 1999, using the headings: electrical, electric and magnetic fields, hypersensitivity, dermatitis and allergy. Older papers were taken from references of papers selected at the first stage as well as from two recent reports, one from Europe (European Commission, 1997) and the other from the United States (Portier and Wolfe, 1998). The NIOSHTI<sup>(R)</sup> with OSHLINE was also consulted, as well as a Quebec expert in occupational hygiene (L. Laliberté, Institute de Recherche en Santé au Travail). Contacts were established with two European scientists (Dr Mueller from Switzerland and Pr Leitgeb from Austria) to get recent data from Europe.

## 2. DEFINITIONS

### 2.1 Terms of reference

Many terms are used to name hypersensitivity to electric and magnetic fields. *Hypersensitivity to electricity* seems to have been first used by Knave et al. (1992) to describe health problems triggered by exposure to VDU, fluorescent lighting, or electrical devices. *Electric hypersensitivity* was also used to describe similar

clinical portraits by Bergqvist and Knave (1992) and Anderson et al. (1996). Other synonyms used are *electrosensitivity* (Bergqvist, 1997), *electromagnetic hypersensitivity* (European Commission, 1997; Portier and Wolfe, 1998), *electrical hypersensitivity* (Sandström et al., 1997; Portier and Wolfe, 1998) and *electrical sensitivity* (Grant, 1995). A more general term, “*environmental illness*,” has also been used by Arnetz and al. (1995) to describe apparently the same clinical portrait.

Several definitions have been given for such diverse designations. A definition has been proposed recently which seems adequate to us: “electromagnetic hypersensitivity” is “a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic or electromagnetic fields (EMFs)” (European Commission, 1997).

As assumed by the title of this review, we will use in this paper the term proposed by the California Public Health Institute: *hypersensitivity to electric and magnetic fields* (HSEMF). It seems preferable to us due to our focus on extremely low frequency fields where electric and magnetic fields are considered separately (Levallois et al., 1997). HSEMF is then defined in this review as “a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric and/or magnetic fields of extremely low frequency.”

## 2.2 Clinical portraits

The clinical portraits are sometimes complex, but it seems that two general pictures could be described as HSEMF (Knave et al., 1992; Bergdahl, 1995; European Commission, 1997): 1) a group of symptoms (“syndrome”) usually appears or worsens during exposure to a specific source of electric and magnetic fields, and 2) most of the time this occurs at work and these symptoms diminish during absences from work (weekends, holidays, etc.).

### 2.2.1 Dermatological Syndrome

This syndrome or group of symptoms was the first to be described in the literature. It is mainly related to exposure to VDU and mostly has a good prognosis. The symptoms are mainly subjective (itching, burning, stinging, etc.) and sometimes objective, but nonspecific (rashes, dry and rosy skin), and are mostly localized to the face.

### 2.2.2 General Syndrome

This syndrome is less well-defined, but usually concerned with different health disorders associated with or without skin problems: functional symptoms of the nervous system (dizziness, fatigue, headache, difficulties of concentration, memory problems, anxiety, depression, etc.), respiratory problems (difficulty breathing),

gastrointestinal symptoms, eye and vision symptoms, palpitations, etc. All are without any indication of organic lesion. These symptoms are triggered with exposure to different electrical devices and appliances (office equipment, fluorescent lights, household appliances, televisions, etc.), often worsen with time and are of relatively poor prognosis.

### **3. DESCRIPTIVE STUDIES**

#### **3.1 Description of the health problems**

Many studies have tried to clarify the health problems related to HSEMF. Most of them have concentrated their effort on skin problems but some have considered other health issues.

##### **3.1.1 Dermatological Problems**

###### *3.1.1.1 Case studies*

The first observations of dermatological problems in relation to exposure to EMF came from doctors in Norway. They described a few cases of facial rash among VDU operators (Lindén, 1981; Nilsen, 1982).

Lidén and Wahlberg (1985a) then presented the evaluation of a group of 166 Swedish patients referred for a diagnosis of rosacea or perioral dermatitis. Only 25% reported being exposed to VDU and among them only eight alleged worsening of symptoms from VDU work. Most of the cases were mild, and the authors concluded that a relationship may exist between rosacea and VDU work.

Berg (1988) presented a paper on 201 patients referred for various skin disorders attributed to VDU. Most were rosacea (pustular and papular, and telangiectatic), seborrhoeic and atopic eczema, acne and lentigo. Most of the symptoms were itching, burning and pain. The skin problems occurred mainly on the cheek turned towards the VDU and were rather mild. Eighteen patients claimed that their skin problems improved overnight and 21 % did so over the weekend.

Berg et al. (1990a) presented the report of an histopathological study of 83 patients reporting skin complaints (with and without skin lesions) supposedly associated with VDU and of 51 subjects with no exposure to VDU and with or without skin lesions. All the patients had skin punch biopsy laterally on the cheek. While histological changes were found in relationship to skin disorders, no difference was found between people exposed and those not exposed to VDU.

More recently Johansson et al. (1994) presented an histopathological study on two cases of “screen dermatitis.” Using immunohistochemistry they found that after a “provocation,” with exposure to an ordinary TV set, that somatostatin-positive cells disappeared. The significance of the findings is unknown, but it seemed

to have convinced the authors that real biological changes are present in this disorder (Gangi and Johannsson, 1997).

Few papers have been published from North America. Our Medline search found only a letter to the Editor published by Feldman in 1985 presenting the case of a middle-aged man with redness and itching on hands and forearms after starting working with VDU. The other papers found were mini-reviews using European literature (Fisher, 1986; Cormier-Patry, 1988; Perry, 1991).

#### *3.1.1.2 Population studies*

The first important dermatological population study was published by Lidén and Wahlberg (1985b). Seventy-four (74) subjects selected from a group of 96 office employees from the Stockholm region who mostly worked with VDU and who complained of skin symptoms in a questionnaire were examined by occupational dermatologists. Of the 61 subjects who had current skin lesions or recent symptoms 37 were found to have objective lesions when examined. The most common of these were eczema, dry skin alone, seborrheic dermatitis, rosacea and acne. Only seven people of the 37 reported that their problems worsened at work. None had facial rashes as had been previously reported in the short reports from Norway.

Berg et al. (1990b) presented a report of an epidemiological study of 809 selected office employees. All had a clinical exam to assess potential facial skin problems. One hundred and forty nine subjects were found with clinical facial diagnoses, of which the more common were rosacea, dry skin alone, atopic dermatitis, acne vulgaris, seborrheic dermatitis and nonspecific skin symptoms. The only diagnosis that was significantly more common among the VDU workers was “nonspecific skin symptoms,” defined as : persons with mild or no skin rash, but with pronounced subjective symptoms such as itching, pain, and burning sensations.

Bergqvist and Wahlberg (1994) did a follow-up study on the previous group of people studied by Lidén and Wahlberg (1985b). Two hundred and ninety-nine (299) subjects with and without complaints of skin problems were examined by an occupational dermatologist after one hour of regular work. The examiner was blind to their VDU status. The face, neck, chest, hands and arms were examined. Seventy-six subjects were found with skin diseases, of which the commonest were seborrhea, eczema, acne, and lentigo. A nonspecific erythema was also noted by the dermatologist in 17 subjects. Seborrheic eczema and non-specific eczema erythema were more common in VDU users, but without any relationship to duration of VDU use. Most of the skin lesions were found on the face region and were mild and symmetrical. In the discussion the authors noted that their definition of rosacea (papulopustular rosacea) did not include milder forms of rosacea (thematotelangiectatic rosacea) considered in previous reports. Of the 73 individuals who



reported skin symptoms, only 24 (33%) were given a definite diagnosis of skin disease. The authors commented that factors related to work conditions (humidity, high perceived work load, and limited rest break) could explain the higher prevalence of skin diseases found in VDU users.

In summary, the dermatological problems described are mild, mostly subjective (burning, itching), sometimes objective but nonspecific (dryness and redness). These symptoms are reported by a limited number of subjects and are worsened by work with VDU, and this is reported especially in Sweden.

### **3.1.2 General Problems**

Few studies have focused on general problems associated with HSEMF. Most of the data published on this subject are included in skin studies.

In the first important dermatological study (Lidén and Wahlberg, 1985a), some data on general symptoms were also reported. All subjects with skin symptoms were compared with the rest of the entire study population. Eye discomfort, musculoskeletal symptoms and headache were found significantly more frequently in people reporting skin symptoms. No details were provided regarding the specificity and severity of these symptoms.

In one of their first presentations on the different clinical aspects of “hypersensitivity to electricity,” Knave and al. (1992) presented the medical history of 32 afflicted people. Skin complaints were the first symptoms reported by most of the subjects, but nervous system symptoms were first reported by 10 subjects and eye symptoms by seven. Nervous system symptoms were functional, such as dizziness, tingling, fatigue, weakness, headache, depression and memory lapses. Other symptoms, such as difficulty in breathing, sweating and heart palpitations, were also reported by these subjects. Nervous system symptoms increased with age, had onset more insidious than skin disorders, were more common in relationship with other electrical equipment than VDU, and had relatively poor prognoses compared to the skin syndrome.

Rea et al. (1991) presented preliminary data on an experimental study of American patients who were alleged to be EMF-sensitive. During the exposure challenge that will be described later in this report and apart from some dermal symptoms, the following general signs and symptoms were reported: neurological (tingling, sleepiness, headache, dizziness, unconsciousness), musculoskeletal (pain, tightness, spasm, fibrillation), cardiovascular (palpitation, flushing, tachycardia, edema), oral/respiratory (pressure in ears, tooth pain, tightness in chest, dyspnea), gastrointestinal (nausea, belching), and ocular (burning). However, several of the study patients were referred to the investigators for “multiple chemical sensitivity.”

Bergdahl (1995) compared 10 patients with symptoms presumably caused by VDU (video group, “VG”) and 10 patients with symptoms reported to be due to exposure to other electrical equipment (electric group,

“EG”). While skin disorders were the most frequent complaints in the two groups, general symptoms were more frequent in the EG. Only pain symptoms were significantly increased in the EG, but there was also a statistically nonsignificant increase in the EG for the symptoms of fatigue, dizziness, headache, difficulties in concentration, memory problems, various eye symptoms, palpitations and gastrointestinal symptoms. Psychological profiles of the two groups were also compared using different psychological scales. People from the EG differed significantly from the VG: they scored less on the socialization scale, were more fatigued in the personality scale, and had more difficulties in concentrating, taking the initiative, and getting on with people in the functioning scale. The author concluded that patients with symptoms presumed to be caused by “electricity” differed psychologically from patients having problems caused by VDU.

In summary, the general symptoms sometimes found associated with the skin disorders described previously are mostly functional and nonspecific and mainly refer to the nervous system and eventually to the gastrointestinal, cardiovascular, ocular and respiratory systems. The psychological component of the syndrome seems important and is considered by some authors as a proof of that HSEMF is a manifestation of somatization or conversion of stress (Lidén, 1996). Globally, this syndrome has been rarely studied and always on a limited scale, which precludes a generalization from the findings.

### **3.2 Prevalence of the health problems**

To our knowledge, no study has tried to assess the prevalence of these symptoms in general populations. However, few attempts have been made to assess the extent of the problem in some specific populations.

#### **3.2.1 Epidemiological Studies**

In the Lidén and Wahlberg study (1985b), carried out in Sweden by questionnaire, 18 % (74/395) of the VDU operators reported skin lesions, compared to 15.6% (22/141) in the unexposed group. As mentioned previously, only 50% of the subjects reporting skin disease had current skin lesions and among these only 19 % (7/37) reported that it was worsened by their work.

In a questionnaire survey done in Singapore, Kohl et al. (1990) reported a one year prevalence of dermatological complaints of 12 % among 672 VDU operators. The prevalence of symptoms was similar among users of cathode ray tube or plasma display screens, the latter are assumed to produce lower exposure to EMF.

In a cross-sectional study done in Sweden, Berg et al. (1990b) found that the prevalence of reported rashes and skin symptoms was 34.7% among VDU operators (954/2751) and 18.8% among nonusers (178/946). As reported previously, the prevalence of clinical diagnosis among a random sample of these people was 18.4 % (149/809) but it varies according to specific diagnosis. The most prevalent disease was rosacea,

present in 10.1% of the sample. Only nonspecific skin symptoms (6.4%) were found more frequently in VDU operators.

Carmichael and Roberts (1992) published the results of a study from Wales done by questionnaire on a group of 1102 office workers (response rate 41%). Facial skin complaints were reported by 14 % of VDU operators and by 11% of nonusers (results not statistically significant).

In their follow-up study, Bergqvist and Wahlberg (1994) reported some prevalence data on skin symptoms and disease during work with VDU. Among the 323 office workers who were evaluated six years after the initial survey (60% from the initial study population), 24.5% reported skin symptoms on questionnaire; 5.7% (17/99) had non-specific erythema noted by a dermatologist; 7.7% (23/299) had seborrhoeic eczema; and 6.4% (19/299) had acne diagnosed by a dermatologist.

Arnetz et al. (1997) presented the results of a study conducted in Sweden on 133 employees of an insurance company who all worked in the same building. They reported that “more than 50% of those who worked with computers reported that they had health symptoms induced by VDU-related work.” The checklist included musculoskeletal, respiratory, dermatological, gastrointestinal, neurological and memory problems. Thirty-five percent reported that they could work for only between a half hour and three hours with VDU because of these problems, but only 10% reported that they suffered from “hypersensitivity to electricity and VDUs.” Ten of 13 afflicted subjects reported that these symptoms were experienced only at work.

In summary, few population studies have been done on the subject. Most were carried out in Sweden in very local populations possibly already alerted by media coverage. It is therefore difficult to have a precise idea of the prevalence of these problems.

### **3.2.2 Other Reports**

A group of “experts” of the European Commission recently tried to assess the extent of “electromagnetic hypersensitivity” in Europe (European Commission, 1997). Questionnaires were sent to 138 centers for occupational medicine and similar organizations (COMs) and 15 “self-aid” groups (SAGs) from 15 different European countries. Response rate was 49% for the COMs and 67% for the SAGs. Questions were asked about the frequency, type and severity of cases of “electromagnetic hypersensitivity.” While it is difficult to draw statistics from such a semiquantitative survey, the report of the European Commission (1997) stated that the prevalence estimated ranges “from less than a few per million (COM estimates from United Kingdom, Italy, and France) to a few tenths of a percent (SAGs in Denmark, Ireland and Sweden) and with severe cases with generally one order of magnitude of lower occurrences.” It was also reported that an Austrian investigation found that the number of people who believed that they are “electromagnetic

hypersensitive” but do not actually have any problems related to EMF may be higher. No data were provided to support this. Details of the European survey were given in the appendix of the report. It was found that the cases from Northern European countries in particular were associated mostly with work exposure, while cases in Germany and Ireland were associated only with sources at home. Other countries, like France, reported mixed exposure. Nervous system and skin symptoms were more frequently reported, and extremely low frequency fields as well as radio frequency source exposures were reported to be associated with these symptoms.

Blomkvist et al (1993) presented some quantitative data in a Congress on the severity of HSEMF in Sweden. The survey carried out in 118 care centers covered by the Swedish Foundation for Occupational Health and Safety for State Employees found that among 1650 VDU users with skin symptoms, 150 (9.1%) had serious problems leading to sick leave or transfer to other work. Among those, 60 had considerable limitations of life style even at home.

#### **4. ETIOLOGIC STUDIES**

Most of the etiologic studies conducted on HSEMF and published in peer review journals have focused on skin symptoms. Case-control and experimental studies (provocation studies) have tried to assess the role of exposure to electric and magnetic fields as well as other environmental factors.

##### **4.1 Case-control studies**

Three case-control studies, all focusing on skin disorders in relationship to VDU, have been published to date. We will summarize them below.

Berg et al. (1992) compared 19 cases with facial skin symptoms associated with work with VDU to 28 other VDU operators without symptoms. All were selected among a cohort of 809 office employees and worked more than 20 hours a week on VDU. No difference was found between groups with regard to age, gender, job classification or years of VDU work. Subjects with skin disorders reported more work-associated eye complaints. Blood levels of prolactin and thyroxin were found to be significantly elevated in those with skin disorders when compared to controls during the workday, but not during leisure. Employees with skin complaints reported more mental strain on psychological measurements. No environmental measurements were done in this study and few details are given on the medical and psychological evaluation. The authors concluded that their study tends to demonstrate that VDU health complaints are the product of psychophysiological responses to the “techno-stress” present in the VDU environment. They also suggest that HSEMF with rather similar symptoms as “multiple chemical sensitivity” may have the same etiological base.

Bergqvist and Wahlberg (1994) presented a cross-sectional study on 353 office workers in seven companies in Stockholm. Skin diseases were assessed by dermatologists and found present in 24 subjects. Environmental and organizational variables were measured at the workplace. No association was found between current levels of electric and magnetic fields and skin disease (either diagnosed or reported by subjects), but low humidity was associated with a diagnosis of seborrhoeic eczema. Organizational conditions during VDU work, such as perceived high work load and inability to take breaks, were associated with skin symptoms. The authors concluded that skin symptoms reported by VDU workers seemed to be associated with conditions specific to VDU work.

Stenberg et al. (1995) compared 85 cases of facial skin disorders to the same number of referents matched according to age, gender and geographical area. All participants had to perform at least one hour of VDU work daily. A dermatological evaluation was provided for each case and control, and a psychological, organizational and environmental evaluation was done through a questionnaire. Measurements of EMF and other environmental factors at the work sites were also done. In a multivariate analysis the following variables were found associated with the disease: atopic dermatitis, high work load/support index, amount of VDU work greater than 4 hr/day, exposure to fluorescent tubes with plastic shielding, background electric fields greater than 30V/m, and low skin-cleaning frequency. The authors concluded that skin symptoms reported by VDU operators have a multifactorial background. The same results were published in a companion paper by Sandström et al. (1995). A complementary analysis presented by Eriksson et al. (1997) tends to support the possibility of interaction between psychological factors and electric fields.

In summary, three case-control studies, all from Sweden, seem to demonstrate that skin disorders in VDU workers are associated with the general organizational environment (workload, stress) of VDU work and that electric and magnetic fields from VDU probably play a minor role in this disease. Electric field background and exposure to fluorescent tubes were found associated with symptoms in one study.

## 4.2 Experimental studies

### 4.2.1 Provocation Studies

The European Commission (1997) recently reviewed 10 “provocation studies,” trying to evaluate the role of EMF in HSEMF disorders. Four studies were done with patients suffering from VDU work-related skin disorders and six studies on cases with a general syndrome of “electromagnetic hypersensitivity.”

Unfortunately, we had access to only five of these studies (the others were published in proceedings not available in North America). We will use the general summary of the European Commission (Table 1), and we will present in greater depth the results of the available publications.

Most of the studies seem to use some kind of cross-over design, with exposure on or off for different time periods, keeping the patient blind to the exposure. The distinctions made by the European Commission report between the different health problems (skin problems versus “electromagnetic hypersensitivity”) could only be verified for the available studies. For these studies, there was some overlap between the two designations and most of the studied patients were exposed to VDU.

#### *4.2.1.1 Skin disorders and VDU*

Among the four studies on VDU-skin disorder patients, two were completely negative (Hammerius and Swanbeck) and two gave some positive results (Oftedal and Sandström). We were able to review only the Swanbeck et al. (1989) and the Oftedal et al. (1995) studies.

Swanbeck and Bleeker (1989) were the first to publish the results of an experimental study trying to assess the effect of EMF from VDU on triggering skin problems. Thirty patients were evaluated who had been referred to the department of Dermatology of Göteborg, Sweden, because of facial skin problems which they felt were caused by VDU. Half had been without skin problems before starting to work with VDU and the other half had one of the following problems :eczema, seborrhea, dryness, psoriasis, rosacea or ictyosis.

Two personal computers (A and B) of identical appearance, but with different EMF emissions were used. Field intensities recorded at 30 cm in front of the VDU were:

electrostatic field (25% humidity): A, 0.2 kV/m; B, 30kV/m

magnetic field (1-300 kHz): A, 50 nT; B, 800 nT

**Table 1** Provocation studies with EMFs and selected individuals (European Commission, 1997)

Study	Recruitment <sup>1</sup>	Exposure Situation	Outcome Parameter	Results
<i>Recruited among patients with VDU work-related skin problems</i>				
Hamnerius et al (1993)	30 skin/VDU patients	created fields (ELF, VLF, RF) 1 hr/session	field detection, skin measurements and symptom reporting	Inability to detect fields. Symptoms or measurements not related to fields.
Oftedal et al (1995)	20 skin/VDU cases <sup>1</sup>	real work situations, VDUs and grounded filters (on/off)	skin problem reporting when using VDUs	Weak association with filter being grounded vs not.
Sandström et al (1993)	22 skin/VDU patients (1 non-VDU case)	Created fields (ELF, VLF) varying durations	facial skin problem reporting	8 cases reacted more for certain fields, but not reproducible.
Swanbeck et al (1989)	30 skin/VDU patients	different VDUs (electrostatic and VLF magnetic fields) 3 hr/session	skin problem reporting	No differences between these VDUs. Reactions also when VDUs switched off.
<i>Recruited among cases of declared “electromagnetic hypersensitivity” (EH)</i>				
Anderson et al (1996)	• 16 cases • positive open challenge	real VDU (on/off) 30 min/session	field detection and symptom reporting	Inability to detect fields. Symptoms not related to fields.
Hamnerius et al (1994)	7 cases	• shielded VDUs • magnetic field changes • 1 h/session	field detection, skin measures and symptom reporting	No secure differences of exposure vs shield situation.
Hellbom (1993)	• 6 cases • positive open challenge	real VDU (on/off) 30 min/session	field detection and symptom reporting	Inability to detect fields. Symptoms not related to fields.
Wennberg et al (1994)	25 cases	• created fields (ELF, VLF) • short recurring exposures	field detection, symptom reporting	No relationship between symptoms and fields. 3 cases detected fields, but not reproducible.
<i>Recruited among individuals with multiple chemical sensitivity (MCS) and EH</i>				
Rea et al (1991)	100 MCS and EH cases <sup>2</sup>	magnetic fields created by coil, several challenges	symptoms and physiological parameters	16 individuals did react to certain frequencies. Reproducible
Wang et al (1994)	19 MCS and EH cases <sup>3</sup>	magnetic fields created by coil, several challenges	symptoms and physiological parameters	No relationship between symptoms and fields when challenged.

1 These are based on the best available information, but categories are difficult to separate (at least in the Swedish studies) and may have changed over time. In some studies control groups were also included.

2 These individuals reported both MCS and “electromagnetic hypersensitivity.”

3 This study included individuals with MCS but not with “electromagnetic hypersensitivity.”

Patients worked randomly for three hours on two consecutive days on each VDU. Then were examined by a dermatologist blind to their exposure before and after the session (30 minutes and four to 20 hours later) and were asked to fill out questionnaires about their symptoms. Most of the patients experienced their usual skin problems when working with VDU, but there was no difference between exposure to computer A or B: twenty-two reacted with computer A and 23 with B. Those patients who had reacted were asked to return for a new provocation test but with higher relative humidity (60%) with the VDU that they thought caused them most of the problems. The results were striking: only seven patients of 19 experienced skin problems, and again, no difference was found between the two VDUs. The reactions were mostly subjective, with heating, itching, stinging and reddening. One patient experienced Quincke's edema. In an another challenge (with 60% humidity) 13 patients were evaluated while the VDU was turned off with a cloth over it: 11 out of 13 still experienced skin discomfort. The authors concluded that EMF from VDUs are not of major importance in provoking subjective skin symptoms. A dry atmosphere was noted as a factor increasing symptoms, but was probably of minor importance. They stated that other psychological factors could explain the results.

Oftedal et al. (1995) presented the results of a different study design. Twenty-two subjects with skin symptoms associated with work on VDU were evaluated at their workplaces. For two weeks, baseline data on symptoms were tabulated by questionnaire and dermatologist evaluation. Then a filter for reducing electric fields was put on each VDU (with a randomized schedule of active and inactive filters of two weeks' duration each). All the subjects and their evaluators were blind to the active status of the filter. The electric and magnetic fields were measured at 30 cm in front of the VDU. There was considerable variation in the reduction of the fields: both filters reduced the electric fields (static, ELF and VLF), and the difference between the two was slight, but more pronounced for VLF. Symptoms were evaluated each day by participants, and a dermatological evaluation was done at the end of each exposure period. Both kinds of filter reduced skin symptoms and symptoms were less pronounced with "active filters" than with "inactive filters." There was also some evidence of a placebo effect since the inactive filter was as effective as the active filter when first used. Other variables relative to the physical environment (indoor temperature, outdoor humidity) and psychosocial factors (workload) were also considered. Only daily exposure to VDU was associated with symptoms. Findings registered by a dermatologist did not revealed any difference between the study periods with filter use, but the baseline evaluation could not be considered because many data were absent. The authors claimed that their results weakly supported the hypothesis of a reduction of symptoms by reduction of electric fields. In fact, since most of the results were statistically nonsignificant, it is difficult to praise the results of this study. Conscious of the many limits of their study, the authors pledged



“more study...to confirm or deny the role of electric fields” in the occurrence of these disorders. The same investigators failed to replicate their findings (abstract reported by the European Commission report [1997]).

#### *4.2.1.2 “Electromagnetic hypersensitivity” and VDU*

Four studies were classified by the European Commission as studies on cases of “electromagnetic sensitivity” associated with VDU exposure. All of the studies gave negative results in the provocation tests. We were able to review only the Anderson study (1996), and it appeared that it was concerned with patients with VDU-associated skin disorders with some kind of general symptoms. It is therefore difficult to consider that this group really assessed a different kind of disease.

Anderson et al. (1996) did an experimental study to assess the effectiveness of a cognitive-behavioral treatment of such disorders. At the same time they carried out a double-blind provocation study in order to evaluate the possible effect of EMF. Seventeen patients were referred to dermatological clinics in Stockholm for subjective reaction of the facial skin after being exposed to VDU and sometimes to other electric sources such as television or fluorescent lamps. Nine were assigned to the psychological treatment and the other eight to a “waiting list.” The two groups were evaluated with a provocation test before and after 20 weeks of treatment or of being on the “waiting list.” The test consisted of a rest period of 15 minutes for baseline assessment of symptoms followed by a 30-minute test with either electromagnetic exposure or sham exposure to VDU. It was impossible for the patients to determine if the source of the field was on or off. Magnetic and electric fields were measured and confirmed the background exposure when the apparatus was off. The following measurements were reported when the PC was on: 245 nT and 7V/m for ELF, 19 nT and 10 V/m for VLF. The subjects were asked if they thought the apparatus was on or off: they were either wrong or right, without any significant difference. The subjective reactions had no relationship to the presence or absence of EMF exposure, but there was a significant relationship to their personal judgment of whether the PC was on. The authors concluded that they could not find any biological effect of the electromagnetic fields. Since their psychological treatment was found efficient in reducing symptoms, they stated that their study supported a behavioral approach and a psychophysiological explanation to the “electric hypersensitivity.”

#### *4.2.1.3 Individuals with “multiple chemical sensibility” reporting sensibility to EMF*

Rea et al. (1991) presented the results of a study which they labeled as preliminary. One hundred patients treated for some kind of environmental sensitivity (the authors briefly mentioned in their paper that they had been previously evaluated and treated for biological inhalant, food and chemical sensitivities) and who complained of being EMF-sensitive were evaluated in a single-blind screening. They were challenged for three minutes at different frequencies from 0.5 Hz to 5 MHz. The mean intensity of the fields was

presented as “approximately” 2900 nT at floor level and 350 nT at the level of the chair in which the patient sat while being exposed. The imprecision of the exposure measurements, as well as the adequacy of the exposure settings, were settled in a letter to the Editor from Bergqvist et al. (1993). Of the 100 patients first challenged, 25 were reacted positively to exposure with only one reaction to exposure to a placebo. These 25 were compared to 25 healthy volunteers for a double-blind challenge. No detail was given on those volunteers or on the double-blind setting. Of the 25 “hypersensitive” patients, 16 (64%) reacted positively, the majority (53%) reacting to exposure compared to a few (7.5%) that reacted to a blank challenge. In fact, most of the results presented are incomplete, and it was quickly stated that no reaction to any challenge, active or placebo, was found in the volunteer group. The major symptoms reported by the patients tested were presented previously and were mainly neurological, cardiological and respiratory. In fact, most of the paper is presented in a non-scientific way (data imprecision); therefore, it is difficult to give credence to these results. The authors themselves at the end of their article recommend further studies to investigate such effects. The same group tried to reproduce these results with an improved design, but without success (Wang et al., 1994, reported by the European Commission, 1997, and Leitgeb, 1998).

#### **4.2.2 Other Experimental Studies**

Recently, Sandstrom and al (1997) presented a report of a challenge with flickering light in 10 patients with HSEMF symptoms and 10 controls. Patients were found to react more intensively than controls to the exposure as assessed by visual evoked potential. The authors concluded that the patients labeled as HSEMF are hyperreactive to environmental stimulation such as flickering. Due to its sample size this study should be considered as preliminary, and there is no evident relation between the findings and the symptoms reported by HSEMF patients.

More recently, Trimmel and Schweiger (1999) reported the results of a double-blind trial aimed at evaluation the role of ELF (50 Hz, 1mT) in a 1-hr exposure on concentration and memory. They found that among 66 volunteers, subjects self-rating themselves as sensitive to EMF tend to perform less well than others when exposed to noise and EMF. Exposure to noise only had no effect, but the effect of EMF only was not evaluated, and few details are given on the exposure setting.

In summary, most of the experimental literature is concerned with VDU skin disorders. At present there is no scientific evidence for a link of these disorders with exposure to electric and magnetic fields, either ELF or VLF. The general syndrome of HSEMF has not been seriously evaluated by researchers. Two recent preliminary studies found that patients labeled as HSEMF reacted differently to different environmental exposures (flickering light, noise plus EMF) from non-HSEMF patients.

## 5. DISCUSSION

### 5.1 Principal findings

The result of our literature review is rather meager. Few studies have been published on the subject of HSEMF, and several communications have not been presented in peer-reviewed journals. Most of the studies published on HSEMF come from Nordic European countries and are concerned specifically with non-specific skin disorders related to VDU. Very few studies have been done in other countries and nearly nothing comes from North America. The evidence of the existence of a more general “syndrome” associated with HSEMF (including such different non specific symptoms of the nervous system as fatigue, dizziness, headache, depression) is still very weak.

As of now, there is no evidence of a link between VDU skin disorders and the exposure to electric and magnetic fields, but there is some evidence of a link with organizational factors and possibly physical factors such as humidity. Moreover, the provocation studies aimed at evaluating the effect of EMF exposure in a double-blind setting failed to reproduce the symptoms of labeled HSEMF patients, and several indicators demonstrated the important psychological factors in the emergence of such a health problem.

Globally, we consider that the largest amount of the evidence pleads against a role of EMF in the reported symptoms, and moreover that its reality in North America seems rather unlikely. But we acknowledge that the quality of the research on this subject is limited. No good descriptive study is available on the burden of the health problem on a population level, and most of the etiologic research on HSEMF suffers from important methodological problems.

### 5.2 Methodological problems

In fact, many methodological problems were found in relation to the study of HSEMF. First, most if not all the cases reported are of subjects who diagnosed themselves as HSEMF cases. No clear case definition exists and no recognizable criteria are available to confirm this diagnosis. Presentation of symptoms and the alleged causes for the symptoms vary greatly from one country to another, and there is doubt about the specificity of the cases reported. Developing a case definition for such a symptom-based condition is not a simple task, but it is a necessity in order to improve study quality (Hyams, 1998). Some authors have speculated on the possible relation to “multiple chemical sensitivity” and other related clinical portraits (Berg et al, 1992). This certainly should be clarified in order to evaluate the specificity of the HSEMF syndrome.

Most of the studies on HSEMF are also limited by the data available on the exposures reported by subjects or evaluated in studies. The descriptions of the exposure triggering the symptoms is usually rather vague. In general, the exposure reported refers to sources like VDU, which are not recognized as important sources of

exposure to EMF (Kavet and Tell, 1991; Gauvin et al, 1998). Moreover, most of the controlled studies did not evaluate the effect of different kinds of exposure to EMF (for instance, varying frequency, intensity and time course of exposure), but instead focused on a simple exposure setting corresponding to what was usually reported by patients. Usually, no data on quality control of the exposure setting was provided.

Due to the absence of a good case definition and the limited methodology of the studies on HSEMF, it is difficult to determine completely the reality of this possible health problem. The fact that “self-aid” groups seem to attract a large number of people who claim that they suffer from HSEMF is rather intriguing (The Electrical Sensitivity Network, 1998). More studies are certainly needed to clarify the reality of the health problem labeled as HSEMF.

### 5.3 Conclusions of other experts

To our knowledge, few expert groups have reviewed the literature on this topic. In 1991, The International Radiation Protection Association (IRPA), via its Non-Ionizing Radiation Committee, issued a statement regarding the “alleged radiation risks from visual display units.” It concluded its review with, “Based on current knowledge, there are no health hazards associated with radiation or fields from VDUs.” Further research on the possibility that skin disorders may be related to VDU work was recommended (IRPA, 1991).

In 1994, an advisory group of The National Radiological Protection Board (NRPB) of the UK published a report on health effects related to the use of visual display units (NRPB, 1994). The report focused mainly on reproductive outcomes, but a section was devoted to skin problems. It concluded that, “Skin diseases do not appear to be caused by the electric fields from VDU, although there is anecdotal evidence unsupported by epidemiology that in conditions of low humidity the associated electrostatic fields may aggravate existing skin problems.”

In 1997, the European Commission presented a report on the “possible health implications of subjective symptoms and electromagnetic fields” (European Commission, 1997). It concluded that, “The review was unable to establish a relationship between low or high frequency fields and electromagnetic hypersensitivity.” They recommended adequate handling of seriously afflicted individuals. Because of “the inability to clearly describe the syndrome and causation of electromagnetic hypersensitivity,” further research was also recommended.

Finally, in its Working Group report on EMF health effects the NIEHS presented a brief review of the topic of “electromagnetic hypersensitivity” (Portier and Wolfe, 1998, section 4.6.6). Here is the conclusion of this section: “Some individuals have subjective symptoms apparently related to VDT use in the office

environment. The evidence is inadequate to relate such symptoms to the EMF associated with that use ...No high-quality double-blind challenge studies have been conducted which conclusively establish the existence of sensitivity to EMF.”

#### 5.4 The general issue of hypersensitivity

In other respects, we consider that the issue of hypersensitivity should not be limited to the HSEMF studies reviewed in this paper. In a broader sense, hypersensitivity could mean the greater susceptibility of an individual to EMF effects. This could potentially be found for different outcomes possibly related to EMF exposure. For instance, some studies found that certain subjects might be more sensitive to the effect of EMF on melatonin secretion (Wilson, 1990; Wood, 1998). While this is still preliminary evidence and not synonymous with adverse health effects, it seems to support the possibility of individual susceptibility to EMF exposure. Researches on such a topic should not focus only on the rather non-specific symptoms of hypersensitivity described in HSEMF reports, but on well-diagnosed illness.

Individual variations to field perception have been described previously, but at much higher intensities than those usually found in the environment and without reference to symptoms of HSEMF (Portier and Wolfe, 1998). As a matter of fact, the field intensities used in the controlled studies reviewed were not perceived by the patients suffering from HSEMF. Recently, Leitgeb (1998) described variability in the perception of induced currents in 606 subjects. While 2% of the sample seemed particularly sensitive to the currents, no individual reported symptoms of HSEMF.

While the issue of hypersensitivity is still open, it seems clear that there are variations of perception of EMF exposure, but this does not appear to be related to HSEMF symptoms.

## 6. CONCLUSION

The Public Health Institute asked us to review the studies of hypersensitivity of human subjects to environmental electric and magnetic fields. We used all available literature published in peer-reviewed journals as well as some proceedings of scientific meetings.

To date, the literature on the subject is rather meager and suffers from methodological problems. Most of the published studies were done in the Scandinavian countries and focused on dermatological disorders. The other clinical portraits are rarely well-described. Globally, case definition is unclear, and there are no population studies that evaluated the prevalence of this disorder.

The most-studied clinical portraits (dermatological syndromes most associated with VDU work) were evaluated in case-control and in controlled studies, and no consistent relationships were found to EMF

exposure, but other factors such as psychological and organizational factors were implicated in that syndrome. Physical factors like low humidity and dust were sometimes associated with symptoms.

In conclusion, we did not find any substantial grounds to build a framework for helping a risk assessor to take into account the alleged “HSEMF syndrome.” The reality of the problem seems too vague to integrate it into an EMF risk assessment protocol. But there is certainly ground for further research to assess more carefully its reality and its possible burden in North America.

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